On the constancy (or not) of the S/O ratio as derived from HII region observations

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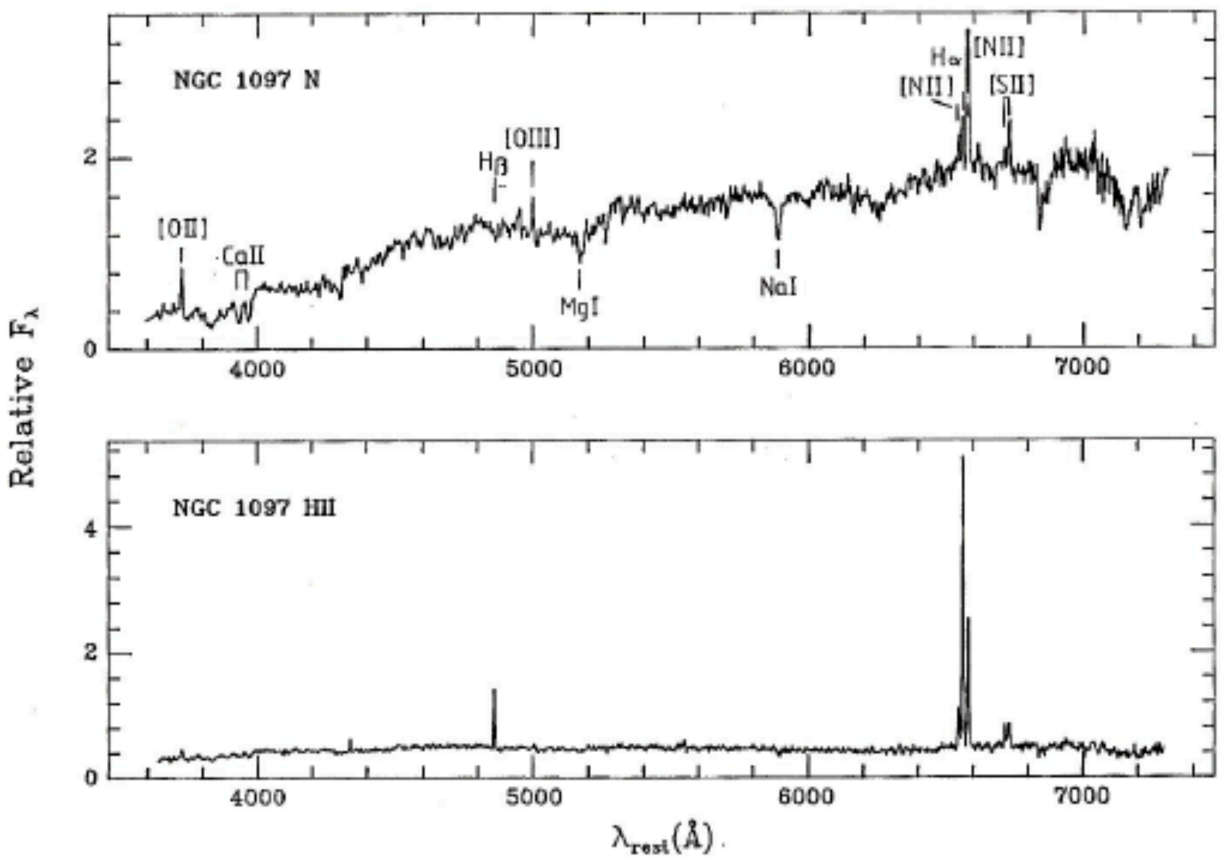
Once upon a time ...



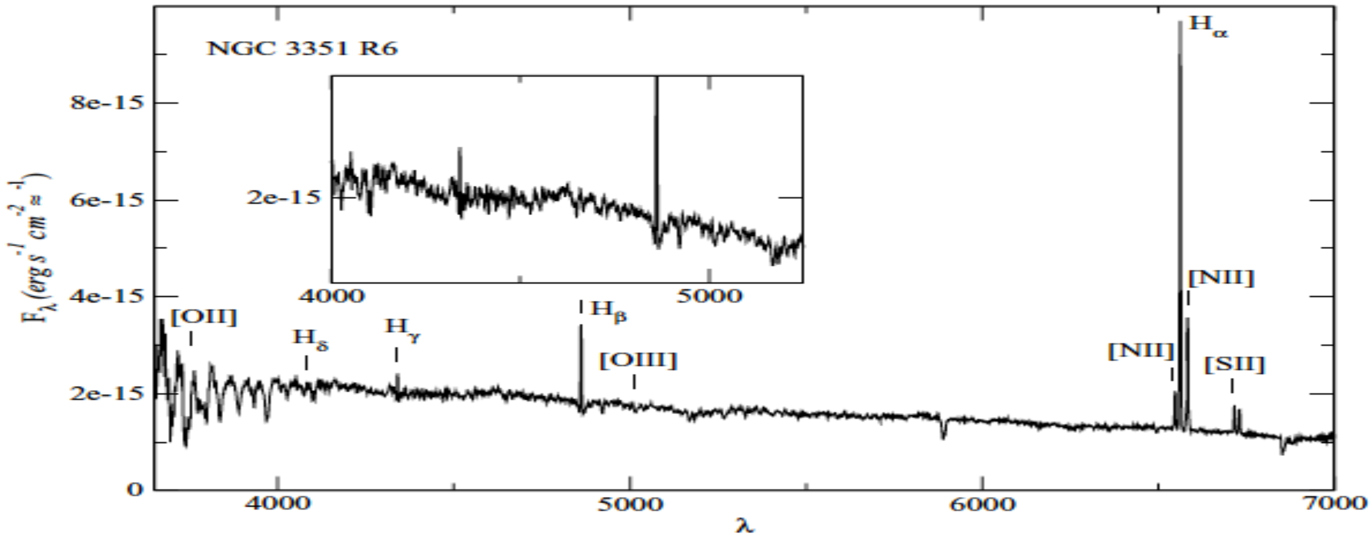
Díaz, A.I., PhD Thesis, 1985

MOVING TO THE RED
Using Sulphur as abundance tracer

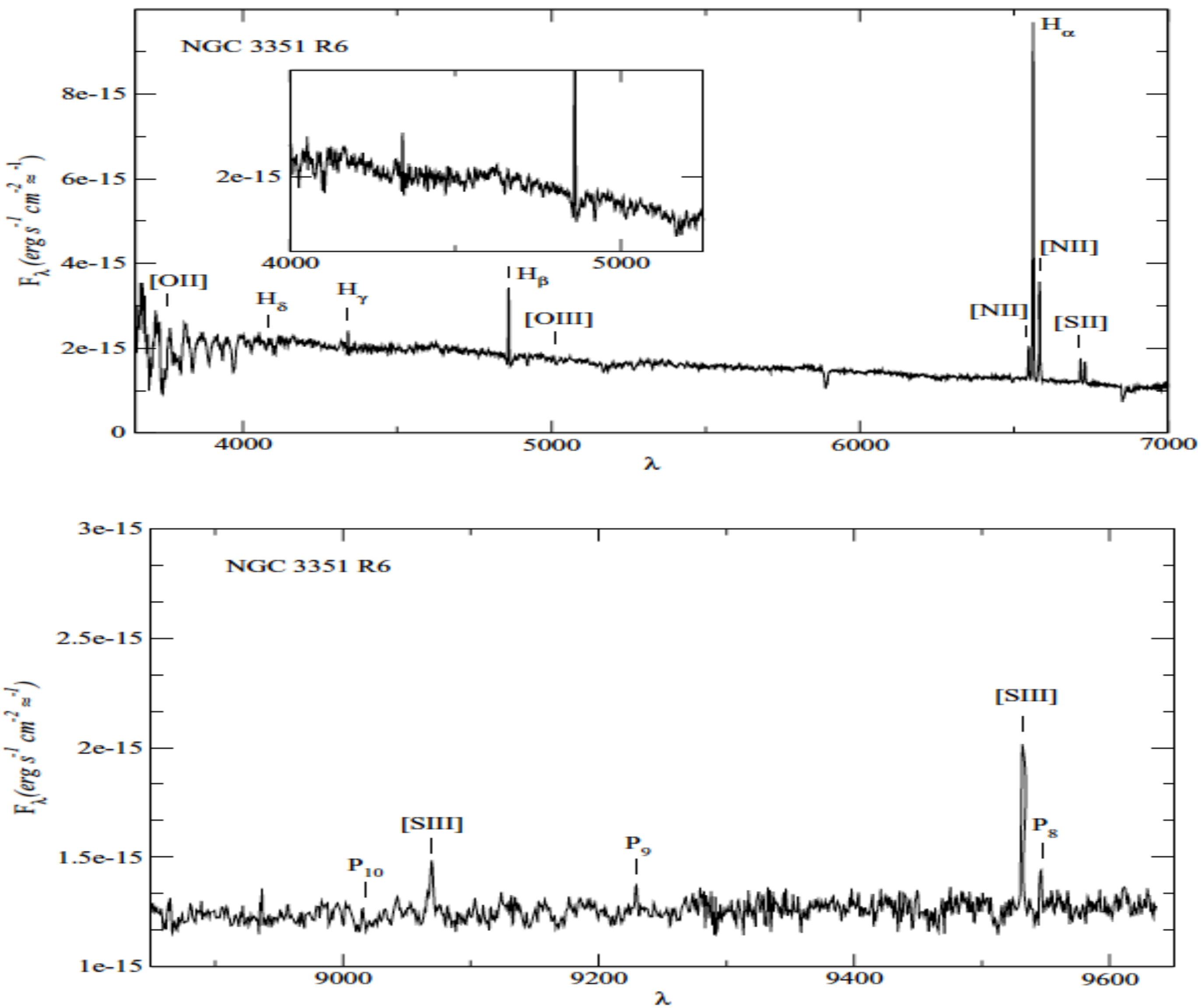
Why using sulphur?
It's all about

$$h\nu \approx kT$$

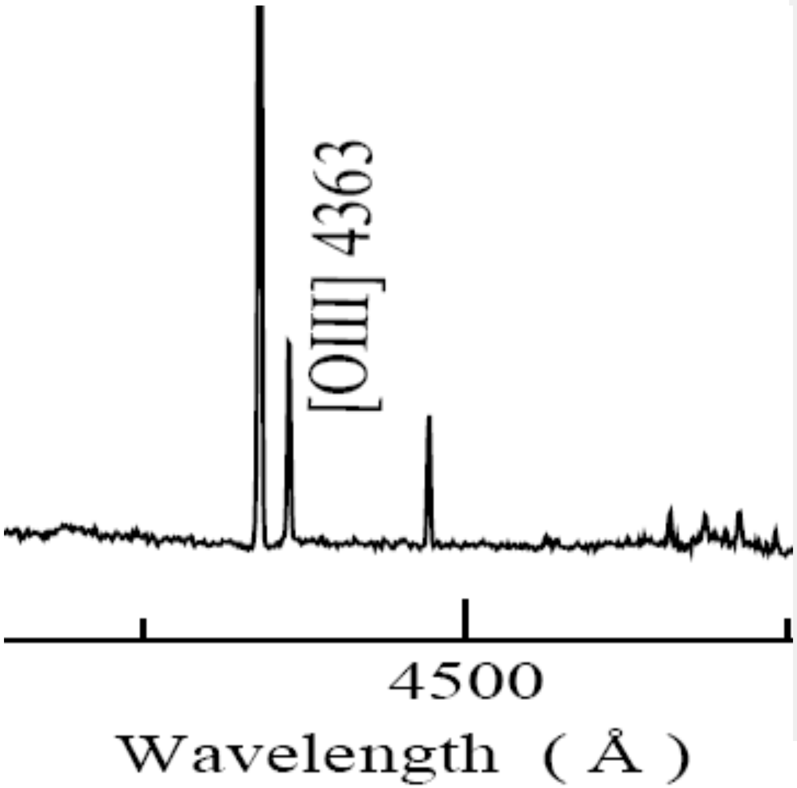
Díaz, A.I. et al. 2007

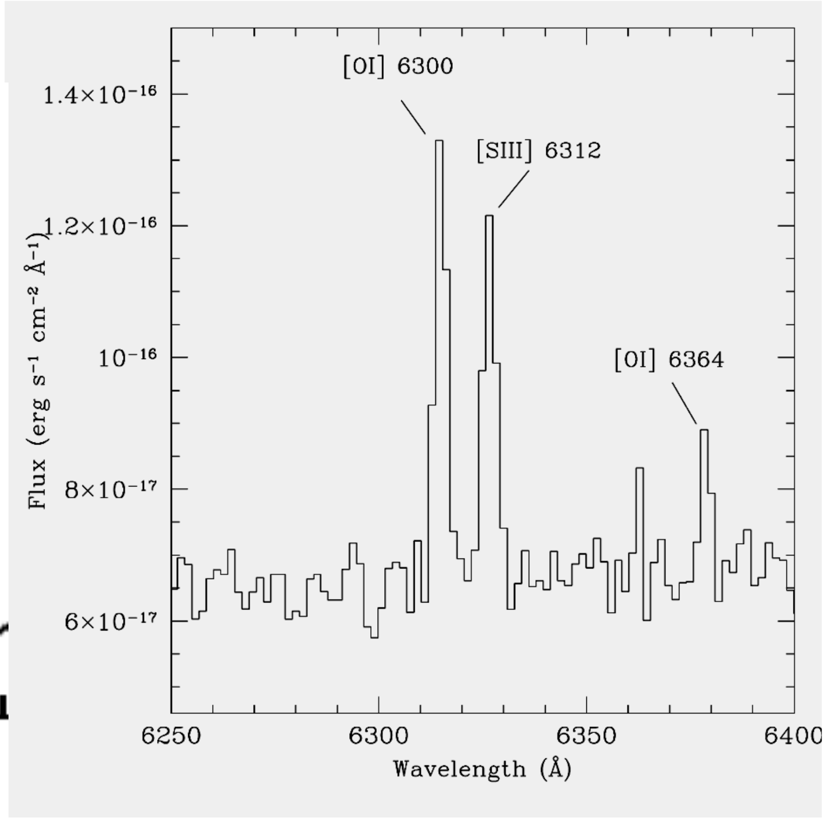


Díaz, A.I. et al. 2007

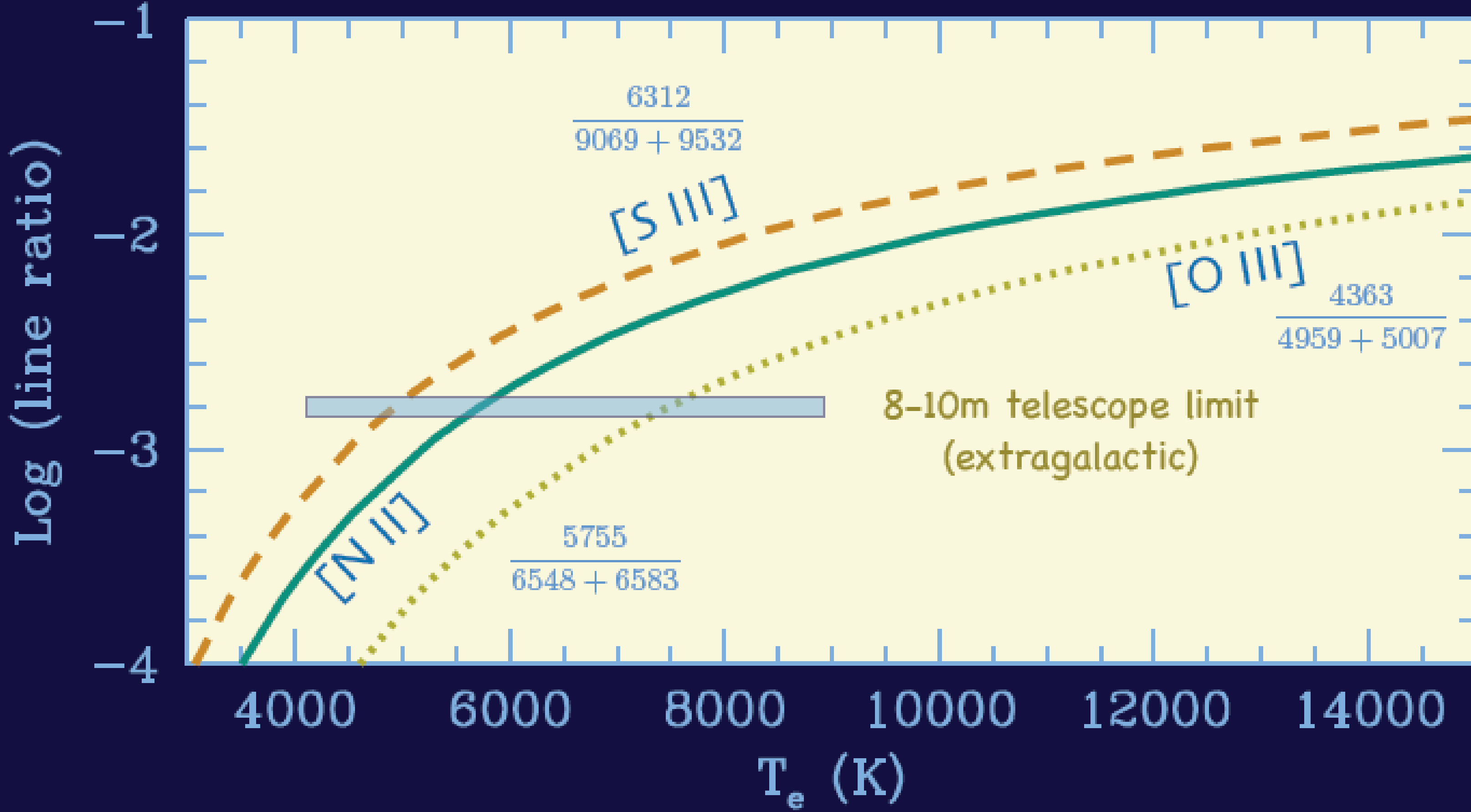


Auroral line detection





Telescope limits (*From Bresolin 2007*)



Using Sulphur as abundance tracer

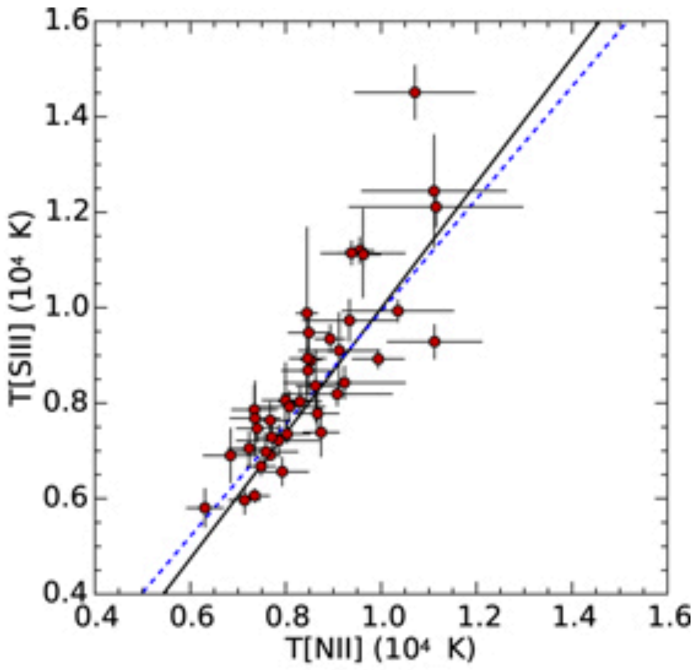
- As for Oxygen, Sulphur is also produced in massive stars.
- **Its yield is supposed to follow that of Oxygen** $\Rightarrow$
  S/O ratio seems to remain constant at
  $\log(S/O)_{\odot} \cong -1.6$.
- Although Sulphur is less abundant than Oxygen, in principle, ***it can also be used as abundance tracer*** providing similar information.

Direct determination of S abundances

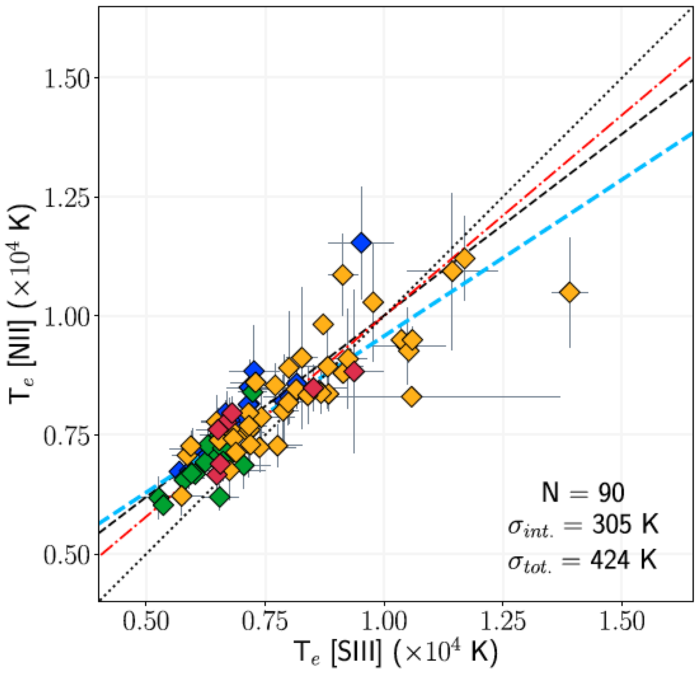
- **Knowledge of line electron temperatures is required**
- T_e([SIII]) is derived from the ratio of auroral to nebular lines at λλ 6312 and 9069, 9532 Å.
- Most of the S in the form of S^+ and S^{2+}, but in most cases S^{2+} is dominant.
- **A certain contribution by S^{3+} is expected in high excitation (low metallicity) objects for which ICF have to be derived.**

Relation between line temperatures

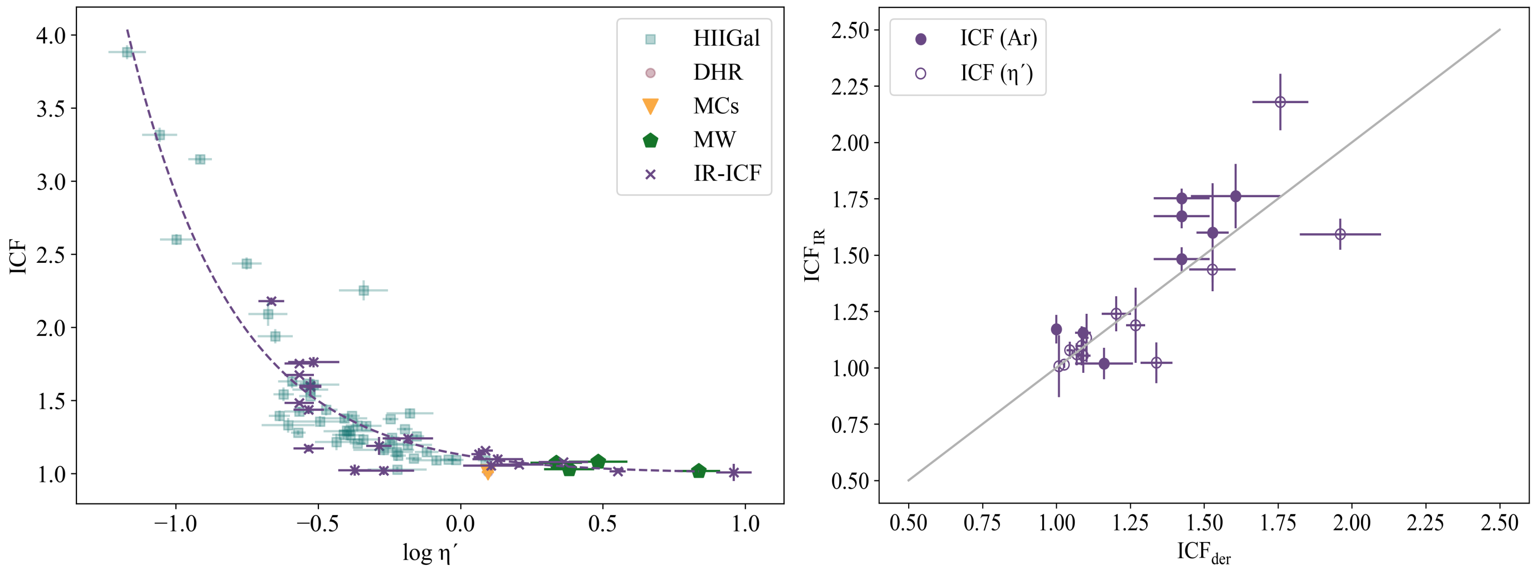
Croxall, K. et al. 2016



Berg, D. et al. 2020

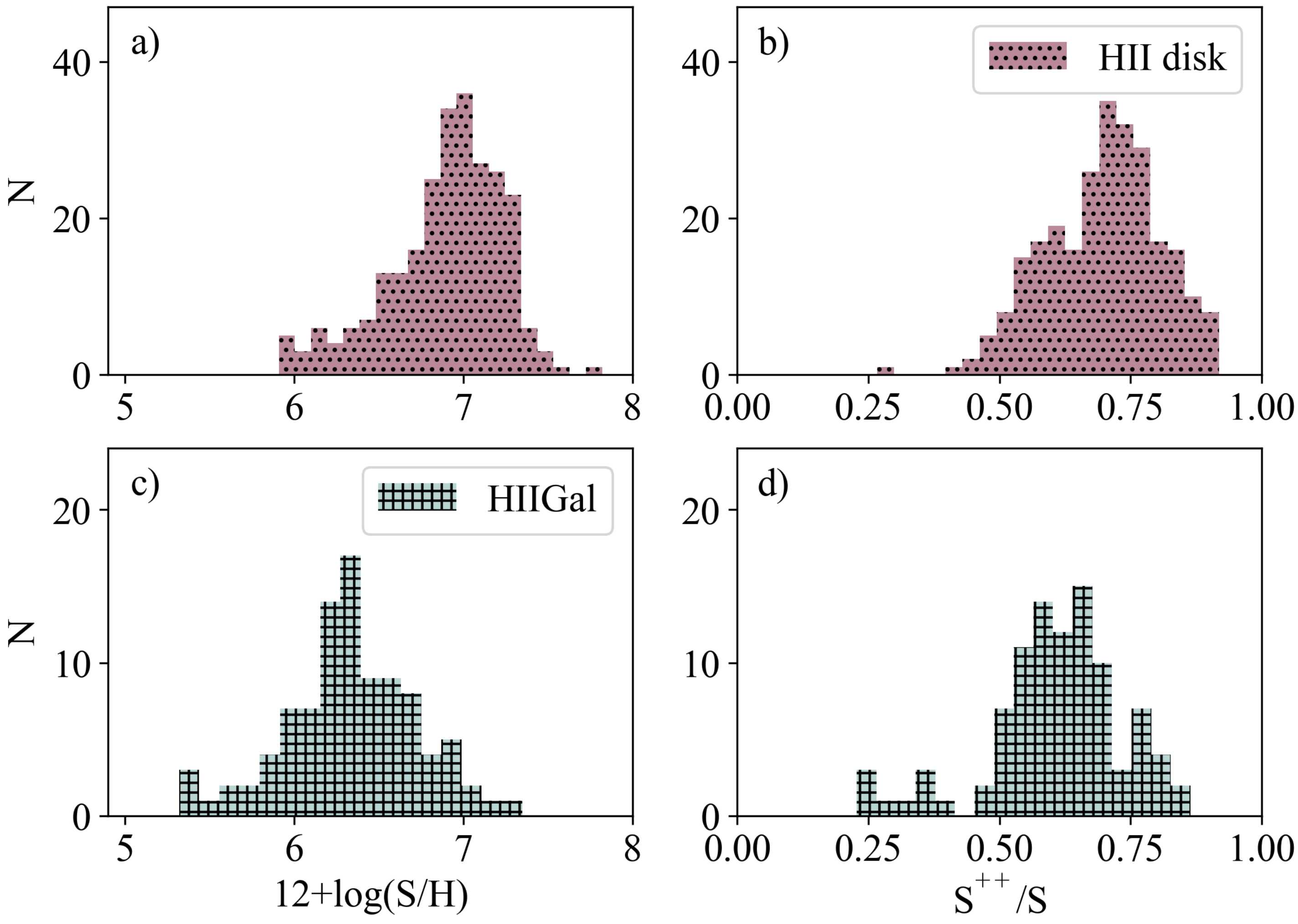


Ionization correction factor

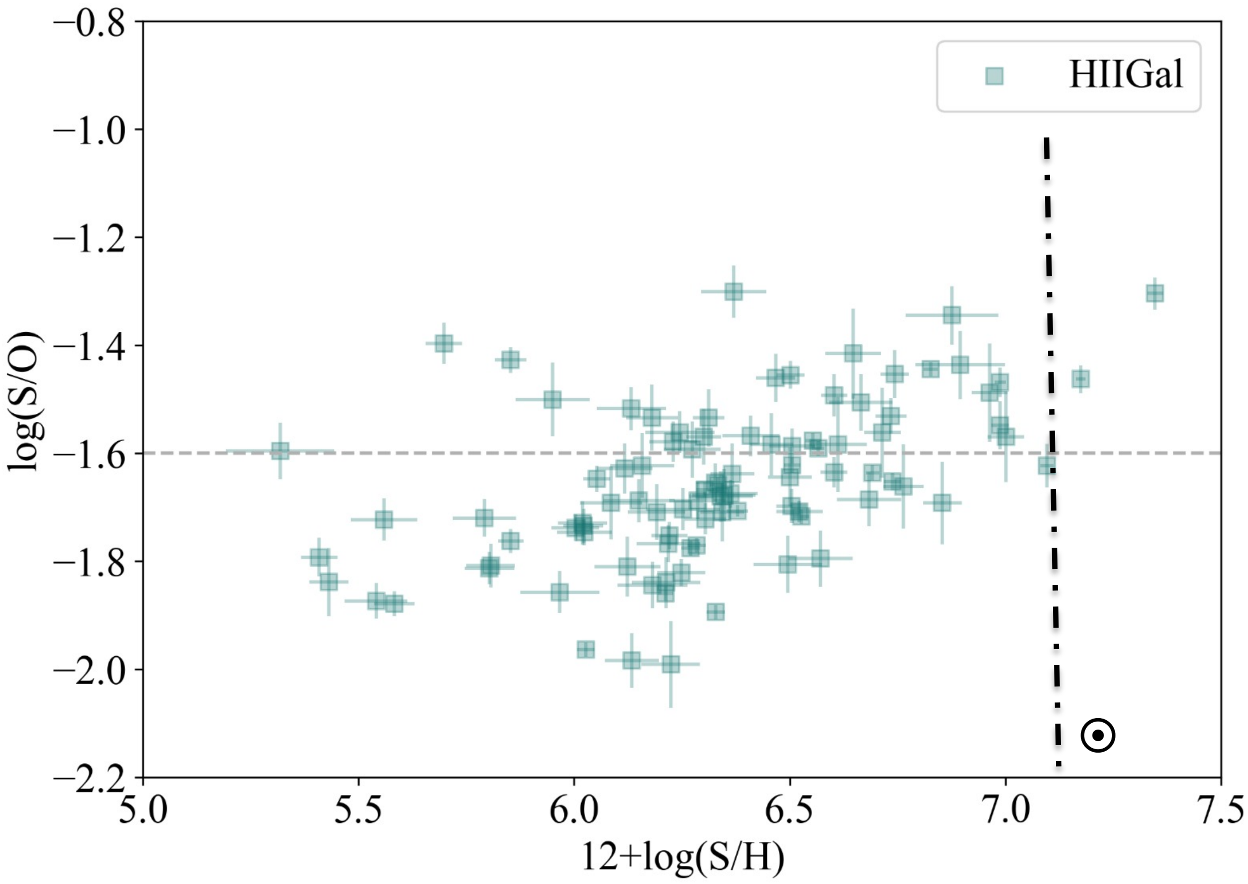


Díaz & Zamora, 2022

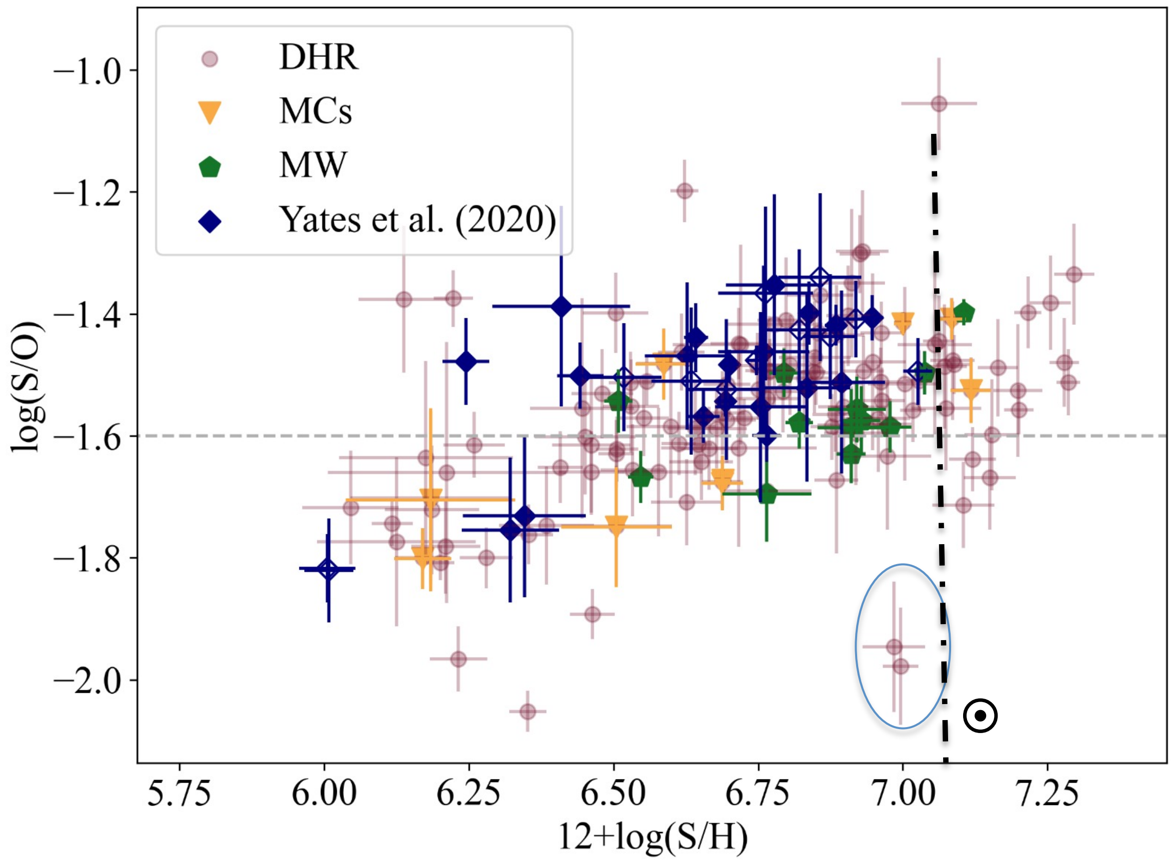
Total S abundances



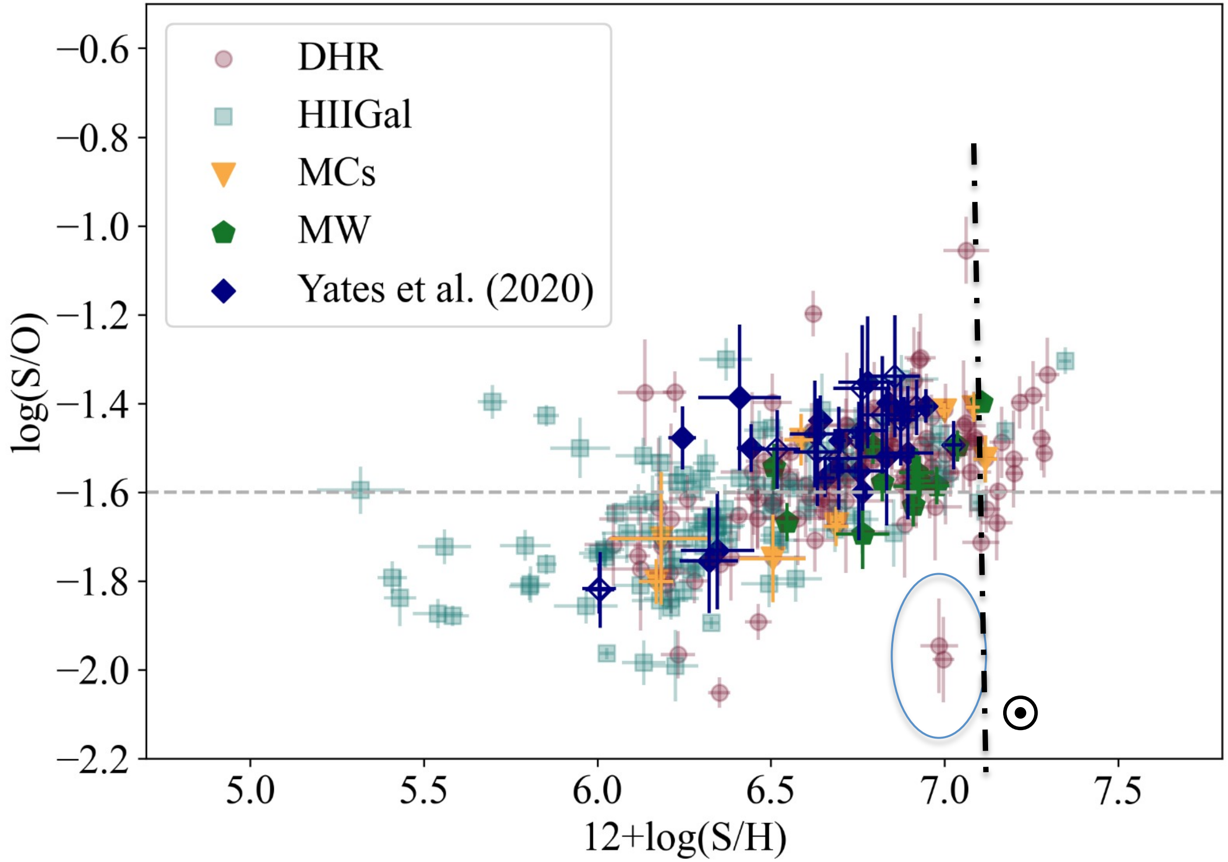
S/O as a function of S abundance
for HII galaxies



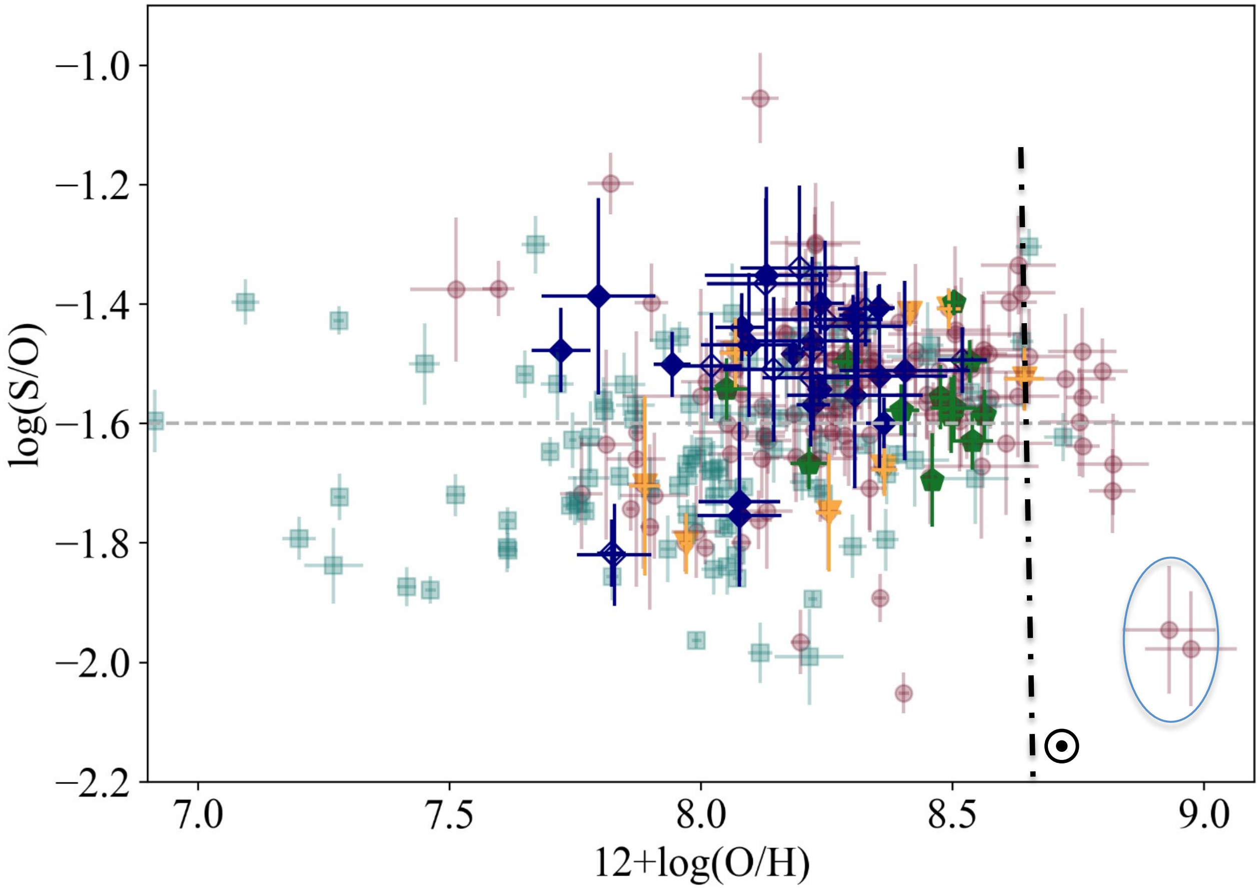
S/O as a function of S abundance
for HII regions



S/O as a function of S abundance
all together



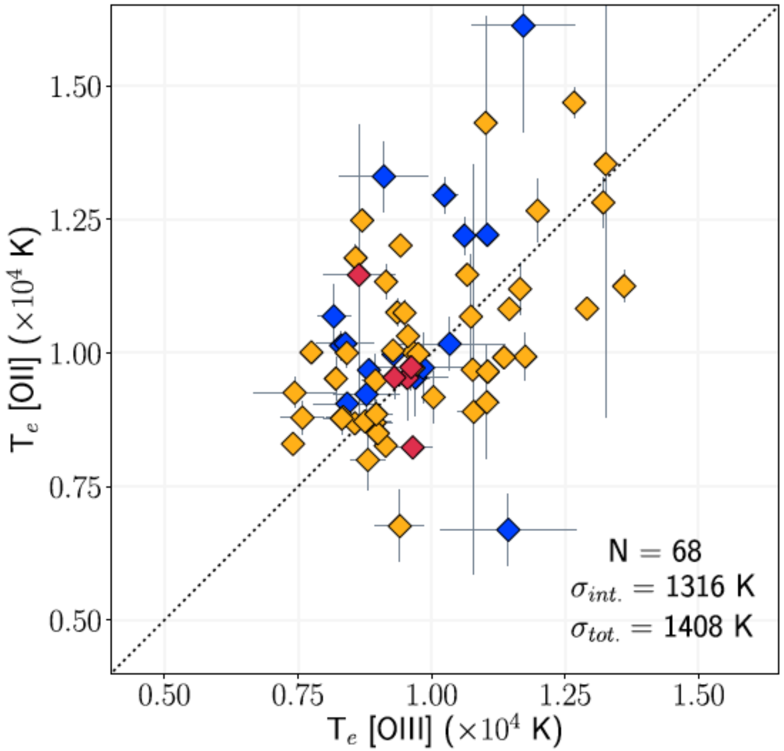
S/O as a function of O abundance

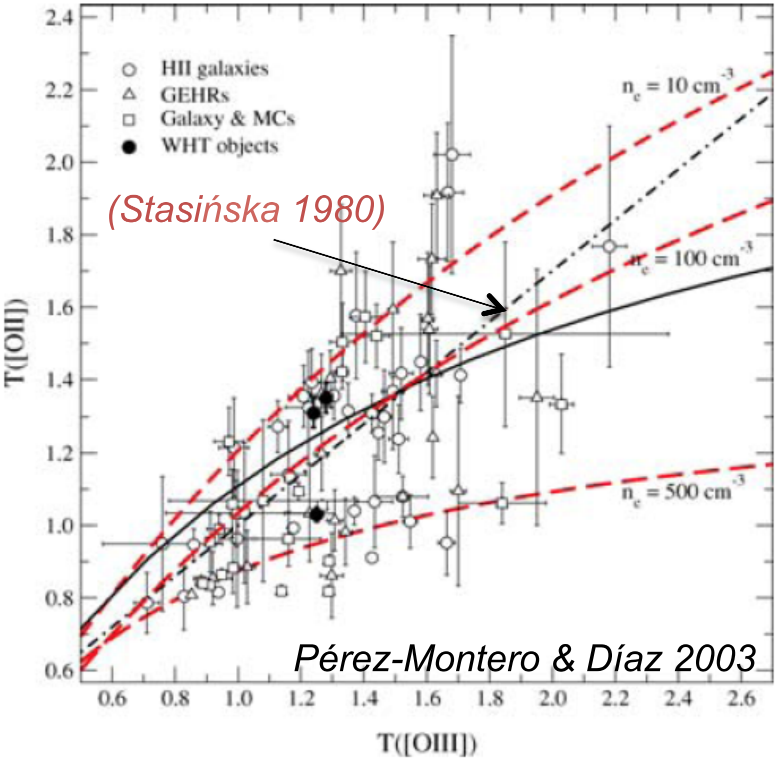


Measuring the O abundance in the high metallicity regime

- In the high metallicity regime $O^+/O^{++} >> 1$, the [OII] temperature is the most relevant.
- But measuring T_e[OII] is not an easy task since *the relation between T([OII]) and T([OIII]) is not so straightforward.*
  - T([OII]) depends on electron density.
  - Empirically derived relation shows a large scatter.
- Thus, it is customary to measure T_e([OIII] while T_e([OII] is predicted from T_e([OIII] with the help of photo-ionization models although this means that t*he determination of O^+/H^+ ratio often carries a large uncertainty.*

The T_e[OII] vs T_e[OIII] relation





Measuring the O abundance in the high metallicity regime

- **And, what's to do when T_e[OIII] cannot be measured?**
- Well, one can derive T_e[OIII] from T_e[SIII] and assume a given relation between T_e[SIII] and T_e[OII]
- We have assumed T_e[SIII] = T_e[OII] which fits within the errors.
- And this is what we get:

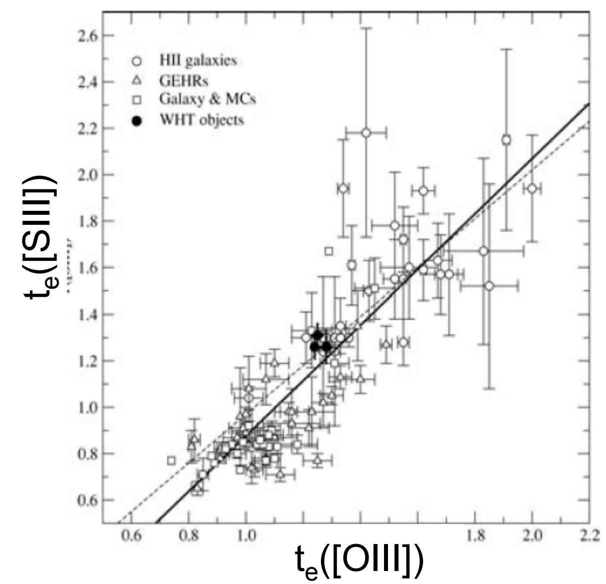
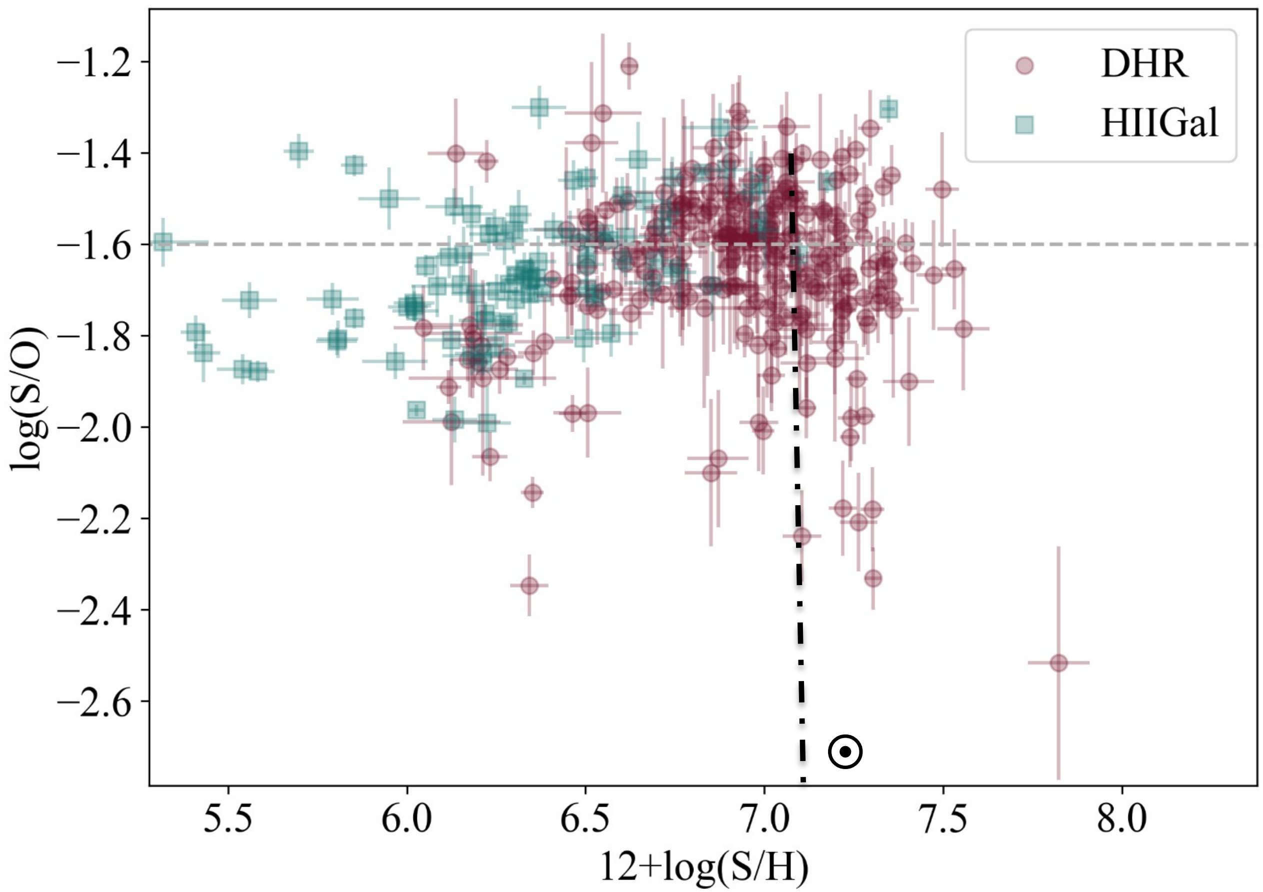
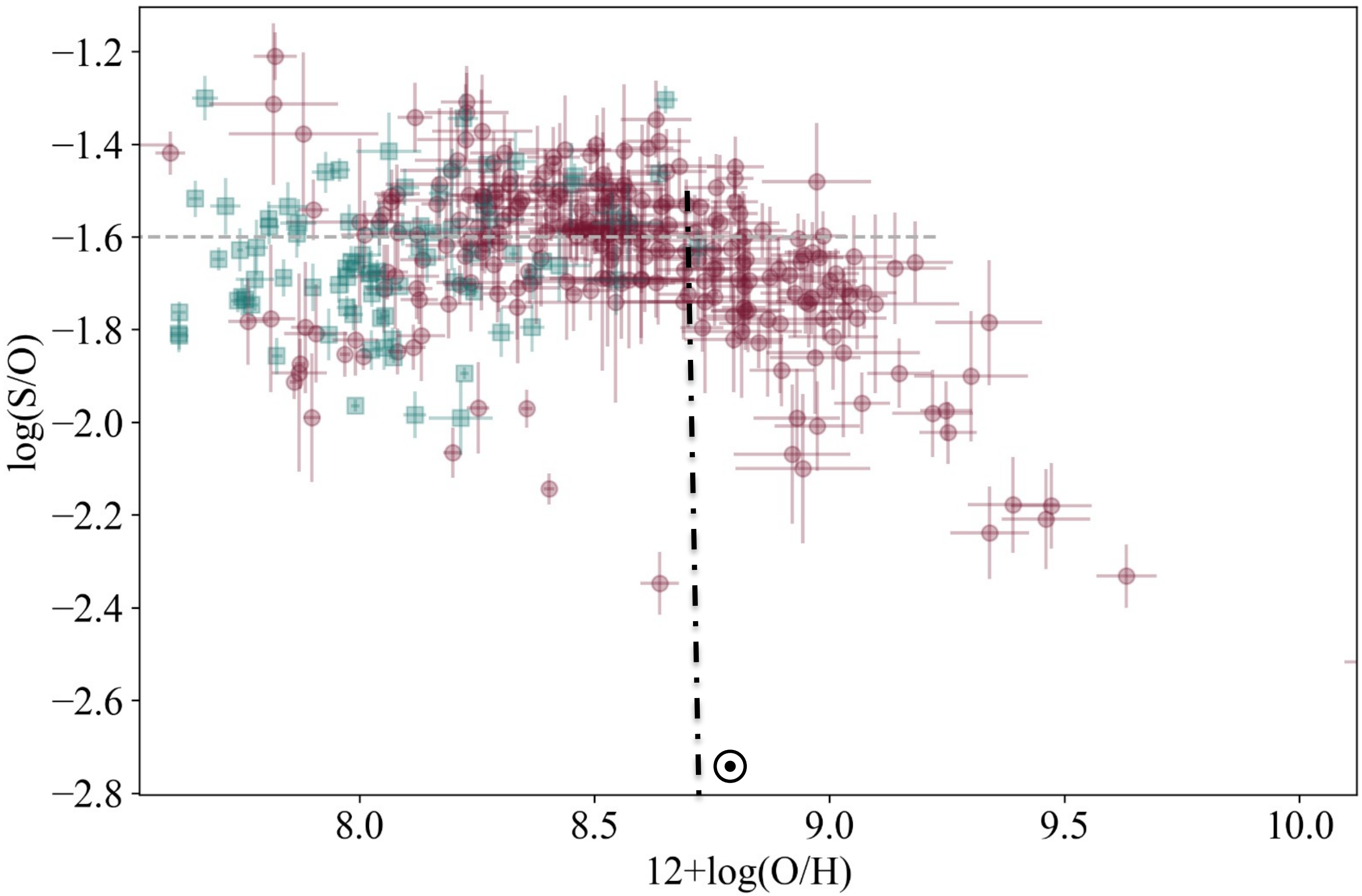


Figure 7. Relation between T([S III]) and T([O III]) for the observed objects (solid circles), and H II galaxies (open circles), GEHRs (upward triangles) and diffuse H II regions in the Galaxy and the Magellanic Clouds (squares), for which data on the auroral and nebular lines of [O III] and [S III] exist (see Pérez-Montero et al. 2006). The temperatures are in units of 10^4 K.

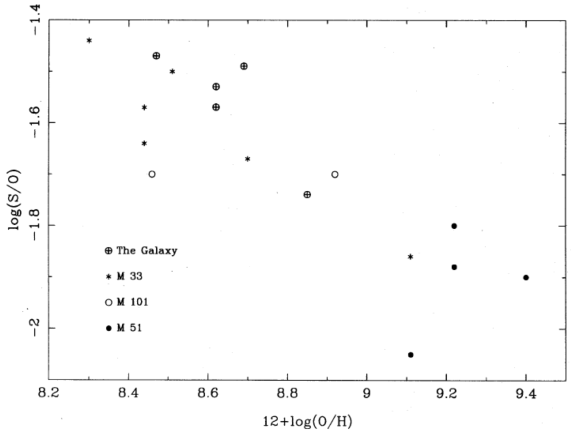
S/O as a function of S abundance



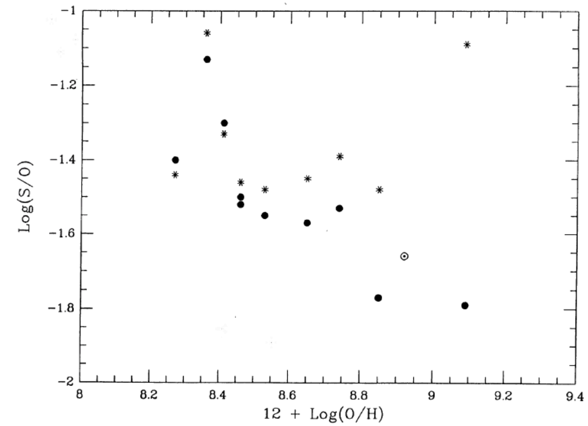
S/O as a function of O abundance



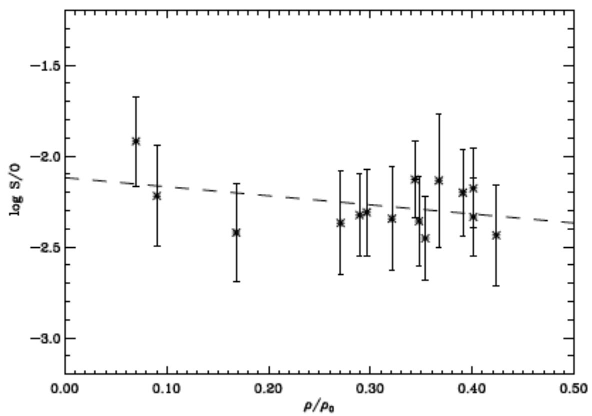
Díaz et al. 1991, M51



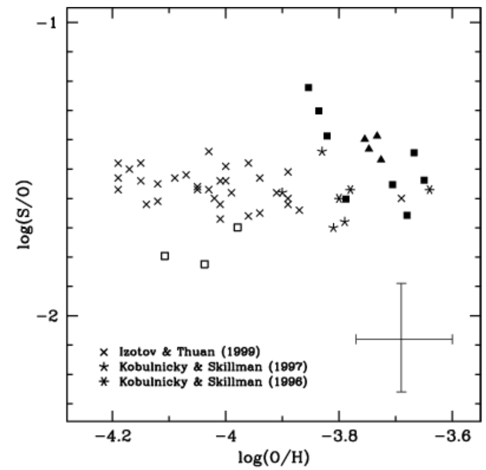
Garnett, 1992, MWG



S/0 ABUNDANCE DETERMINATIONS through the years



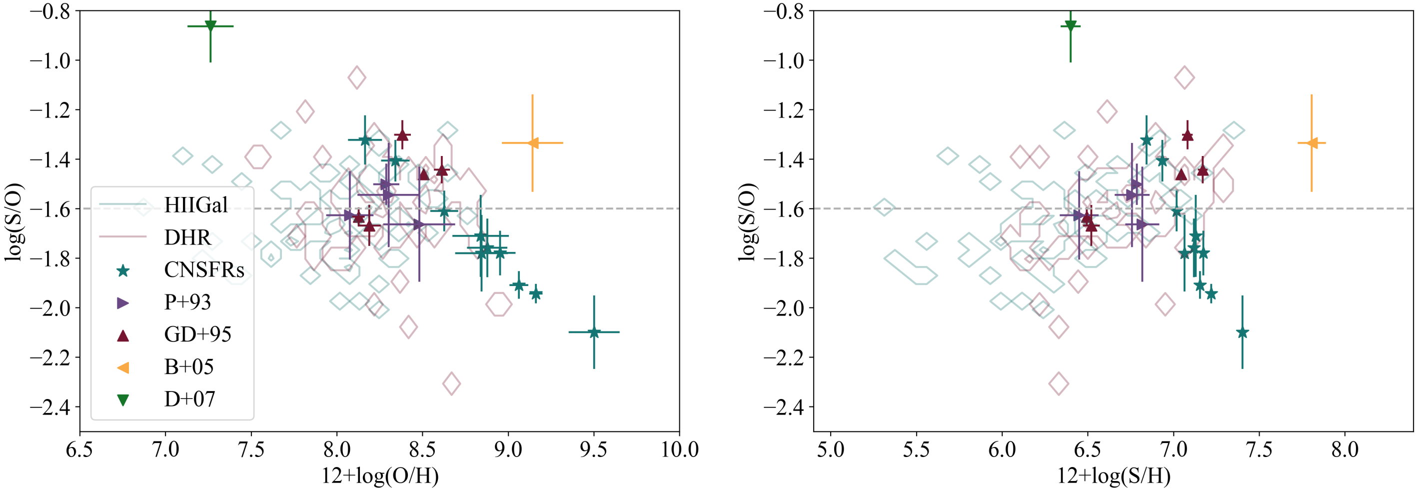
Christensen et el. 1997, NGC 300



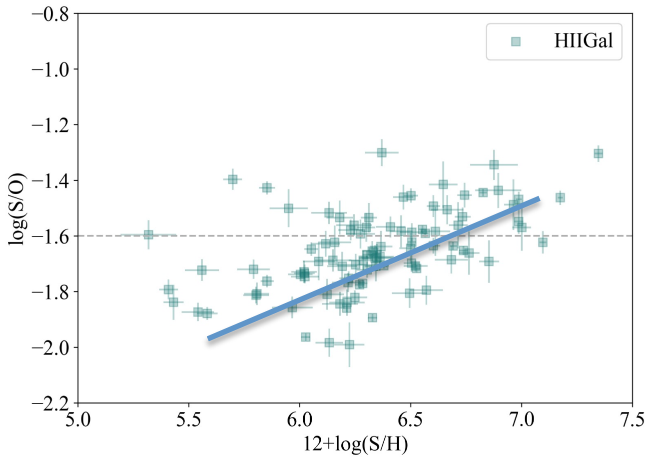
Vermeij & van der Hulst, 2002

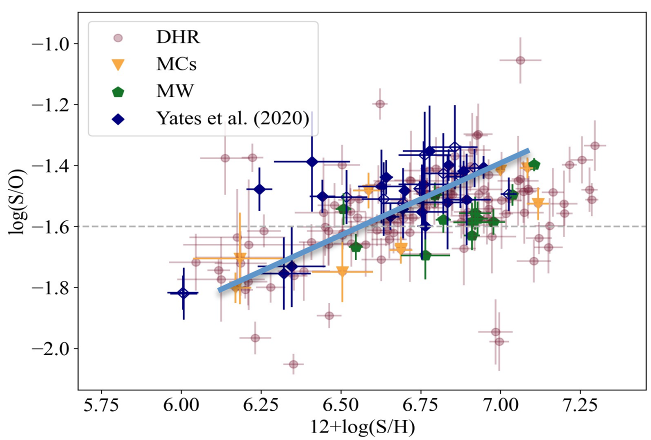
The S/O ratio in CNSFR

From Sandra Zamora's work



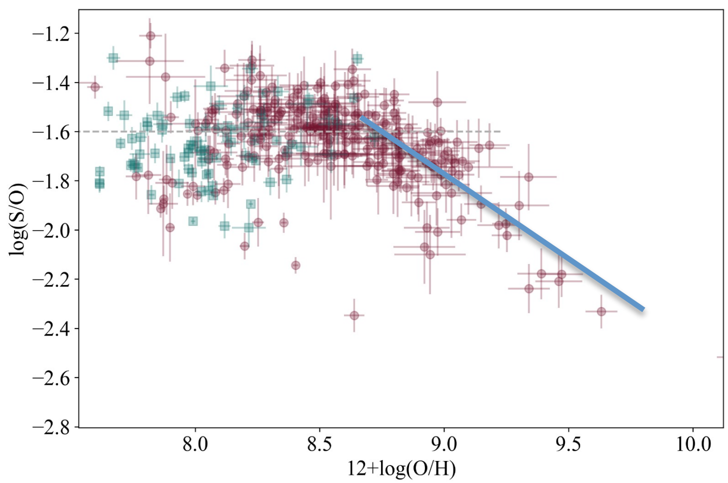
Interpretations?

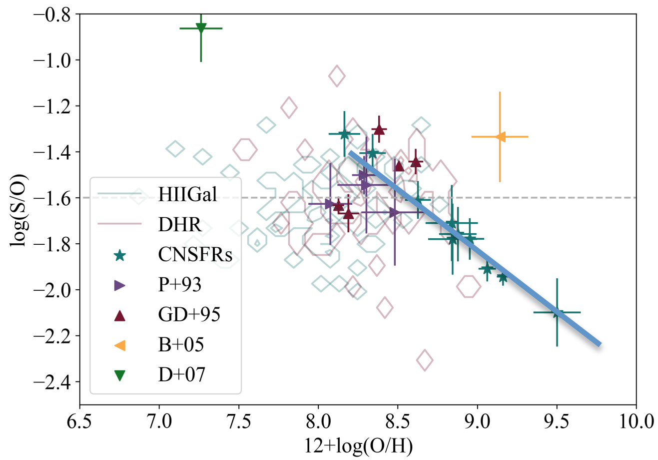




- This trend for metallicities up to the solar value might be atributted to depletion of Oxygen onto grains that would increase with increasing abundance.

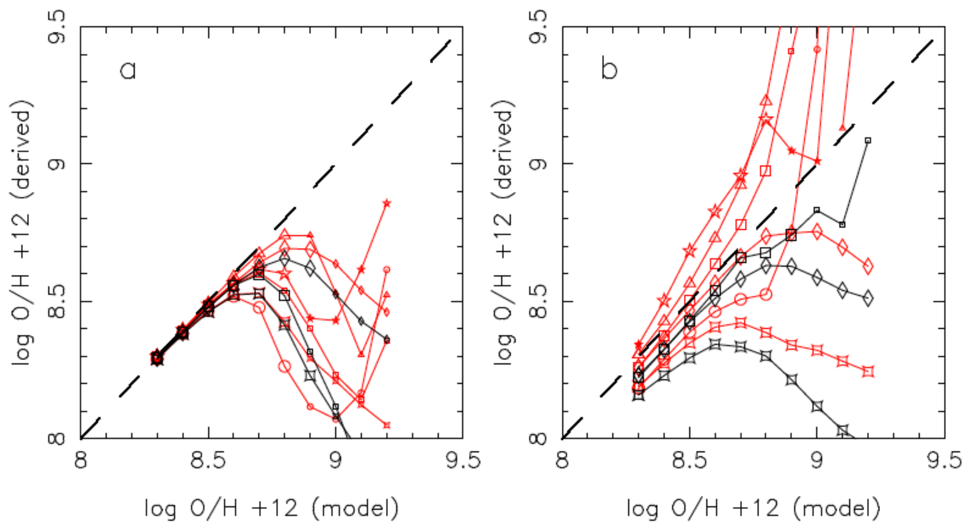
Interpretations?





- This trend is more difficult to explain.
- It could reflect some systematics related to the derivation of Oxygen abundances in the high Z regime.
- Or could be related to stellar nucleosynthesis.

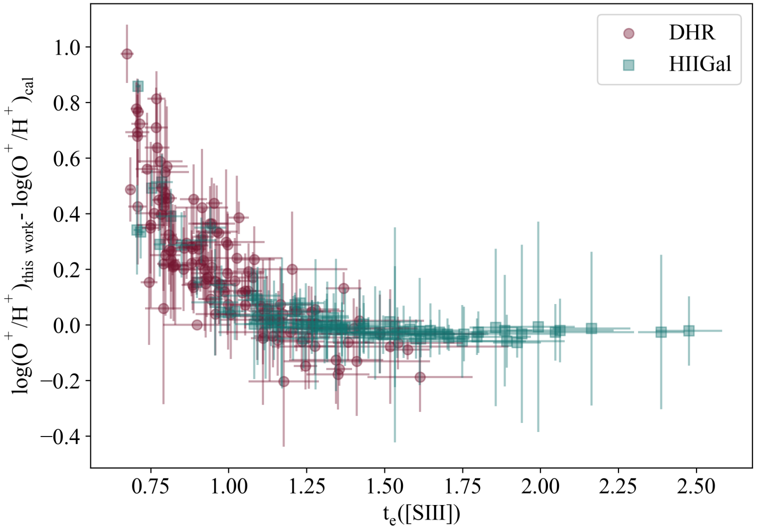
O/H derivation in high metallicity regions



" It is seen that, as long as the metallicity is low, the derived O/ H value is very close to the input Important deviations appear around log O/ H + 12 = 8.6, and may become huge as the metallicity increases. In the case of Fig. 1a, all the derived values are smaller than the input ones, sometimes by enormous factors".

Stasinska, 2005

O/H derivation in high metallicity regions



The figure shows the difference in the O/H abundances derived with the temperature structure assumed in this work, i.e. T([SIII])=T([OII])=T([SII]), and the one commonly assumed, T([OII])=T([SII]) with T([OII]) derived from T([OIII]) with the help of models, against T([SIII]). The O/H abundances derived for moderate to high metallicity Hii regions using the standard method should be taken with caution.

Conclusions

- The assumption that the S/O ratio be constant in all cases and metallicity regimes might not be that good!
- The relations found have to be supported by photo-ionization models.
- Results on the derivation of Oxygen abundances in the high metallicity regime should be taken with caution.
- It may result that our knowledge of the distribution of gaseous abundances is not complete.